



Small, S., Cresswell, L., Lovatt, F., Gummery, E., Onyango, J., McQuilkin, C., & Wapenaar, W. (2019). Do UK sheep farmers use orf vaccine correctly and could their vaccination strategy affect vaccine efficacy? *Veterinary Record*, 185(10).
<https://doi.org/10.1136/vr.105472>

Peer reviewed version

Link to published version (if available):
[10.1136/vr.105472](https://doi.org/10.1136/vr.105472)

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Research paper

Title: Do UK sheep farmers use orf vaccine correctly and could their vaccination strategy affect vaccine efficacy?

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Keywords: Orf, ecthyma, vaccination, use, compliance, storage, vaccine efficacy, barriers,
motivators, sheep

Word count: 4623

Do UK sheep farmers use orf vaccine correctly and could their vaccination strategy affect vaccine efficacy?

Abstract

Orf, a parapox virus, is a zoonosis causing a contagious pustular dermatitis, and has a high morbidity in sheep worldwide. Despite a vaccine being available, orf prevalence in England is estimated to be 2% in ewes and 20% in lambs. There is concern that farmers are not complying with the vaccination guidelines and therefore the objective of this study was to investigate if orf vaccine is used correctly on sheep farms in the UK and to identify barriers and motivators of sheep farmers to use the vaccine.

The survey was completed by 570 respondents. The results show several areas of concern; only 27% of respondents used the correct site (axilla), 37% of respondents would use orf vaccine up to a week after opening a vial (shelf life is 8 hours), 33% of respondents would vaccinate their ewes too close to lambing and 73% of respondents did not separate vaccinated and non-vaccinated animals (both leading to infection risk for non-vaccinated animals). When vaccinating, only 53% of respondents were wearing gloves and 31% washed their hands just before and immediately after vaccination. Results demonstrate that orf vaccination is not carried out correctly on all UK sheep farms, which is likely to affect vaccine efficacy. A concern around vaccine efficacy, the 'hassle' of the scratch administration, the 'risk of making it worse' and the zoonotic risk when vaccinating were the most common barriers for using orf vaccine, highlighting the importance of veterinary advice when prescribing orf vaccine.

Keywords

Orf, ecthyma, vaccination, use, compliance, storage, vaccine efficacy, barriers, motivators, sheep

Introduction

Orf, a parapox virus, also referred to as contagious ovine ecthyma, sore mouth, scabby mouth and contagious pustular dermatitis, is a zoonosis and seen as an occupational hazard (1). Orf is highly contagious and reported worldwide (2). While morbidity is high and can be up to 100% (3), mortality is low, usually less than 1%. However, mortality can increase to 50%, often as a result of secondary factors such as stress, immunosuppression or concurrent disease (4). In 2003, a UK study estimated that orf costs the British economy £10 million a year with a profit loss per sheep estimated between £2.70 and £4.00 (5). Nine years later, Lovatt et al. (6) estimated losses between £1.06 and £14.03, considerably higher than the maximum in 2003. The losses reported from this field study included the cost of replacement ewes following mastitis precipitated by orf. In the current economic climate, these avoidable losses are even more important to mitigate; Brexit poses a risk to the future of sheep farming, particularly due to the high reliance on the Common Agricultural Policy (CAP). In addition, maintenance of the countryside is also key to the environment and tourism, which together with other local and regional businesses in the supply chain, sustain the social fabric of local rural communities.

In the UK, there is one licenced orf vaccine (Scabivax Forte, MSD Animal Health, Milton Keynes, UK), which is a live attenuated vaccine. Despite a vaccine being available, the orf prevalence rate in England was calculated as 1.88% for ewes and 19.53% for lambs (7). Based upon a sheep population of 6.7 million ewes and 4.6 million lambs in England (8), this leads to 125,960 ewes and 898,380 lambs infected per year.

There is concern that farmers are not complying with the orf vaccination guidelines (2). Onyango et al. (7) found that a minority of sheep farmers follow the advised protocol of vaccinating both ewes and lambs (8% of total farmers and 18% of those vaccinating). The limited literature available on orf vaccination is available in scientific publications; information that a farmer is unlikely to have access to. Online information on orf vaccination is scarce and although informative videos are available on e.g. YouTube (9) and farming fora, these

sources often rely on personal experience, rather than being supported by scientific evidence.

Although farm animal vaccination compliance and vaccine efficacy is debated industrywide (10), existing literature supports the efficacy of orf vaccine when used for the objective stated in the summary of product characteristics (SPC): 'to reduce clinical signs and/or lesions of the disease' (11). This raises the question of whether current vaccine storage, handling and administration protocols, and the vaccination strategy used are supporting optimal efficacy of orf vaccine.

The objective of this study was to investigate if orf vaccine is used correctly on sheep farms in the UK and to identify barriers and motivators of sheep farmers to use the vaccine.

Materials and Methods

This observational cross-sectional study was reported following the STROBE guidelines (12).

Survey

The target population was anyone in the UK who owned sheep. A paper-based and online survey (Jisc Online Surveys, 2018) was developed. There was the option to be entered into a prize draw for a £100 voucher. The survey was piloted with three sheep farmers and three colleagues owning sheep or involved with the sheep industry. The final survey (provided as supplementary material) contained 36 questions. Participants who did vaccinate were asked questions focusing around various aspects of orf vaccination such as the method of administration, vaccine storage and use, where and how they administer the vaccine, when vaccination would take place in relation to the lambing period and whether they separate vaccinated animals as recommended in the SPC. The survey was available from October 11 until November 29, 2018. A convenience sampling method was employed.

Data analysis

Survey data were analysed using Microsoft Excel 2016 (Microsoft, Redmond, USA) and EpiTools epidemiological calculator (13) was used to perform χ^2 tests on relevant associations; statistical significance level was defined as $P < 0.05$. No sample size calculation was performed prior to the study as the aims were descriptive in nature. Where relevant, quantitative variables such as flock size, were categorised to facilitate interpretation. Answers to open questions were categorised by the author into themes using content analysis methodology (14). If not all respondents answered a particular question, the total number of respondents answering the question was reported and considered as the denominator for calculating a proportion. Multiple answers could be selected for several questions; therefore, cumulative percentages for results reported per question could be greater than 100 per cent. For those respondents vaccinating against orf, an 'incorrect use' variable was created. The variable 'incorrect use' was defined as respondents confirming one or more of the following responses: vaccinating ewes 6 weeks or less before lambing, using vaccine when orf has not been confirmed on farm, using a syringe and needle to apply the vaccine instead of the proprietary applicator, storing the vaccine at room temperature, and using the vaccine up to a week after opening a vial.

Results

Survey uptake

The survey was completed by 586 respondents; 16 responses were removed due to incomplete data. Of the remaining 570 respondents, 36% ($n=207$) vaccinated against orf, 64% ($n=363$) did not and of the 363 respondents not vaccinating, 25% ($n=89$) respondents indicated to have vaccinated against orf in the past. Of the respondents who vaccinated against orf, 57% were using the vaccine correctly, applying the definition of 'incorrect use' as described above ($n=117/207$); N.B. this definition of 'incorrect use' did not include 'correct site'. The majority (95%, $n=540/570$) of respondents completed the survey online.

Demographic respondent data

Most respondents (67%) were 50 years old or younger, 45% were female and 77% indicated to have further or higher education qualifications. The majority of respondents (73%) considered themselves to be flock owners. Flock size ranged from 2 to 4000 adult sheep with 33% of respondents working with a flock of 500 or more sheep (Table 1). Men were more likely to vaccinate than women, and larger flocks were more likely to be vaccinated. When comparing correct use over the different demographics no significant associations were observed, although 'age' and 'role on farm' showed a trend; non-significance may have been due to insufficient sample size to confirm an association (Table 1).

Table 1. Demographic information about survey respondents; P-values in bold indicate a significant difference in the proportion of respondents vaccinating in that particular demographic. The 'correct use' column reports the proportion of respondents for each demographic that vaccinates correctly, no significant difference were observed.

Demographic	Categories	N (%)	Vaccinate	Significance	Correct use	Significance
Age (years) n=569	<30	148 (26%)	35%	P=0.24	50% (26)	P=0.07
	31-50	236 (42%)	35%		60% (50)	
	51-70	166 (29%)	42%		61% (43)	
	>70	19 (3%)	21%		0% (4)	
Gender n=569	Female	254 (45%)	30%	P<0.01	53% (38)	P=0.76
	Male	310 (54%)	42%		58% (76)	
	Prefer not to say/Other	5 (1%)	40%		50% (1)	

Level of education n=565	School education	129 (23%)	40%	P=0.55	55% (28)	P=0.97
	Further education (FE)	211 (37%)	36%		57% (42)	
	Higher education (HE)	225 (40%)	34%		57% (43)	
Role on farm n=570*	Partner/Owner	414 (73%)	34%	P=0.05	57% (80)	P=0.10
	Manager/shepherd/tenant	109 (19%)	49%		68% (36)	
	Worker	87 (15%)	36%		61% (19)	
	Farmer/Family business	44 (8%)	39%		35% (6)	
Flock size n=569	50 or less	100 (18%)	14%	P<0.01	50% (7)	P=0.75
	51-499	277 (49%)	34%		55% (52)	
	500 or more	192 (33%)	51%		59% (58)	

*respondents could tick multiple roles and indicate additional roles as free text

Respondents were geographically widely distributed throughout the UK (Figure 1) with four respondents from the Republic of Ireland.

Figure 1

Vaccination knowledge and experience

All respondents who vaccinated (n=207) used Scabivax Forte (MSD Animal Health, Milton Keynes, UK). The majority of respondents who were vaccinating had been using orf vaccine for more than five years, and the shepherd would be the most likely person to carry out the vaccination. Half of the respondents learned how to vaccinate from their vet. Just over half the respondents who vaccinated did know the clinical signs that indicated effective uptake of the vaccine (Table 2).

Table 2. Survey responses (n=207) regarding knowledge and experience around orf vaccination. P-values indicate non-significant differences in the proportion of respondents using the vaccine correctly for each answer to the five questions.

	N (%)	Correct use (%)	Significance
Approximately how long have you been using orf vaccine?			P=0.25
Less than a year	8 (4%)	62%	
1-5 years	50 (24%)	50%	
More than 5 years	145 (70%)	57%	
Don't know	4 (2%)	100%	
Who administers orf vaccine on your farm?*			P=0.91
Shepherd	167 (82%)	57%	
Worker	36 (17%)	56%	
Owner/Farmer	30 (14%)	57%	
Vet	3 (1%)	67%	
(Vet)student	3 (1%)	67%	
How or from who did you learn to vaccinate sheep against orf?*			P=0.16
Vet	103 (50%)	58%	

Colleague, fellow farmer	63 (50%)	61%	
College	23 (11%)	52%	
Online	16 (8%)	56%	
Family, friends, neighbours	12 (6%)	33%	
Read information that comes with vaccine/applicator	11 (5%)	82%	
Industry representative	10 (5%)	30%	
What orf vaccination instructions did you follow?*			P=0.99
I followed the instructions on the vaccine box/bottle/datasheet	136 (66%)	60%	
I did what I have done previously	98 (47%)	58%	
I followed the instructions on the dispensing label	32 (15%)	59%	
I followed the verbal instructions given by my vaccine supplier	18 (9%)	61%	
I followed the written instructions given by my vaccine supplier	6 (3%)	50%	
Other†	6 (3%)	50%	
Which of the following indicates that orf vaccination has been effective?*			P=0.72
Approximately 2 weeks after vaccination a more or less continuous line of pustules is visible along the scratch made on the skin	109 (53%)	61%	
Approximately 3-14 days after vaccination vesicles and redness may be observed along the scratch made on the skin	105 (51%)	59%	
Scabs dry and fall off by 7 weeks after vaccination	94 (45%)	56%	

Don't know	19 (9%)	47%	
Other [‡]	4 (2%)		

* Respondents could select multiple options. The first three options indicate successful vaccination (11).

† Other responses provided were: 'Followed vet guidance' (2), 'I do what is the most practical', 'I read the instructions but don't necessarily follow them', 'Instructions on applicator', 'Watched online YouTube video'

‡ Other responses provided were: 'Does that mean it works? How can you see the scab?', 'There is a raised mark where scratch has been', 'We do random checks to see if there are any pustules/ dried scabs. Seems to be effective in our flock', 'What are pustules as opposed to vesicles?'

Vaccine administration

The most common location to vaccinate was the hindleg (Figure 2), seven respondents explained they used different locations for lambs and ewes; the tail was used for ewes and the flank, hind leg or elbow for lambs. There was no significant association between respondents using the vaccine correctly ('incorrect use' related to incorrect timing, application, usage and storage, as detailed in materials and methods) and using the correct location (behind the elbow or in the axilla, $P=0.61$).

Figure 2

Almost all respondents (97%, $n=201$) used the orf vaccine applicator to administer the vaccine. Five respondents used a needle (and syringe) and two respondents used the 'old type scratcher'.

When asked 'How do you administer the vaccine?' 90% of respondents chose 'Scratch on the skin just sufficient to break the top layer of skin', 9% of respondents indicated a 'Scratch on the skin just deep enough to draw blood'. Two respondents indicated 'Other'; they

described to use 'a combination of the first 2 options' and 'a scratch in the ear skin to draw blood'.

Just over half the respondents were wearing gloves when vaccinating and 10% of respondents (n=20) cleaned the applicator with disinfectant in between (groups) of animals (Figure 3).

Figure 3

Vaccine storage

Most respondents (93%) knew the required storage temperature for orf vaccine (2-8°C / 36-46°F) and would keep orf vaccine in the fridge. Twenty-six percent of respondents had a temperature logger in their fridge (Table 3).

Table 3. Survey responses regarding storage of orf vaccine. The underlined option indicates the correct answer.

Where do you store orf vaccine? n=207	n	%
Specific fridge used for veterinary medicines only	121	58
Fridge used for purposes other than veterinary medicine e.g. food	80	39
Non-refrigerated drugs cabinet on the farm	3	1
Other [*]	4	2
When did you last check the fridge temperature? n=200		
Can't remember	114	57
I have a temperature logger in my fridge	52	26
I check it every month	22	11
Other [‡]	12	6

At what storage temperature do you consider orf vaccine to remain effective?[†] n=207		
<u>At refrigerator temperature (2-8°C / 36-46°F)</u>	193	93
At room temperature (17-23°C / 63-73°F)	11	5
Below refrigerator temperature (less than 2°C / 36°F)	8	3
Above room temperature (greater than 23°C / 73 °F)	1	<1

^{*} 'Other' responses provided were: 'As answer A, but bottle in use stays on bike as marking lambs in field as I find them', 'In the lambing shed drugs box', 'Store in fridge only till opened not once it is open', 'Stored in separate compartment of household fridge. No children in household so no problem.'

[‡] 'Other' responses provided were: 'never' (5), '12 months', 'Check it when product goes in' (2), 'Checked upon daily', 'it's my kitchen fridge', 'Occasionally', 'Regularly', 'Weekly'

[†] Respondents could select multiple options. Refrigerator temperature (2-8°C / 36-46°F) is the correct answer (11).

Respondents were asked to consider three timeframes within which they would be using orf vaccine after opening a vial; 37% of respondents would be using orf vaccine up to a week after opening (Figure 4).

Figure 4

Vaccination strategy

Most respondents (90%, n=186/207) would only vaccinate lambs, and had commenced in response to a history of disease on the farm. The timing of vaccination varied for both ewes and lambs, with 38% of ewes being vaccinated 7-8 weeks before lambing, and 44% of lambs being vaccinated 1-3 days after birth (Table 4).

Table 4. Survey responses regarding vaccination timing, strategy and target animal. Where appropriate, the correct and/or recommended responses (11) are underlined.

When do you administer orf vaccine? n=206	n	%
<u>I administer orf vaccine as a preventative measure, as orf is/has been present on my farm</u>	<u>196</u>	<u>95</u>
I administer orf vaccine as a preventative measure, even though I've never had orf on my farm	10	5
Which animals do you vaccinate against orf? [†] n=207		
All lambs born on the farm	186	90
All ewes	33	16
<u>Lambs and ewes</u>	29	14
Only replacement ewes	9	4
Some lambs born on the farm [*]	9	4
Other [‡]	6	3
When do you administer orf vaccine in ewes [†] n=42		
<u>Approximately 7-8 weeks before lambing</u>	<u>16</u>	<u>38</u>
Approximately 5-6 weeks before lambing	8	19
Approximately 3-4 weeks before lambing	6	14
Other [¥]	16	38
When you administer orf vaccine in lambs? [†] n=195		
1-3 days after birth	86	44
1-3 days before being turned out into the field	37	19
Between 1-4 weeks of age	56	29
At turnout, during activities such as marking, tailing, worming	10	5

Other [∞]	8	4
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[†] Respondents could select multiple options.

^{*} When ask to clarify a variety of reasons were presented: 'ewe lambs for flock replacement, fattening lambs on farm in January', 'I just vaccinate twins lambs that go away to a grazing that seems to have orf in the ground, home farm doesn't seem to be too bad', 'Only pedigrees', 'Orphans', 'Pet lambs, any weak/poor lambs and entire groups if any early signs are seen on an individual in said group', 'Vaccinate all lambs except crossbred lambs born outside and not kept for replacement. 60% lambs vaccinated'

[‡] 'Other' responses were mostly related to vaccinating rams

[¥] 'Other' responses: 7 respondents would vaccinate ewes around lambing time, 3 respondents would vaccinate ewes at turnout, 3 respondents would vaccinate when buying in, 2 respondents would vaccinate 9-12 weeks before lambing and 1 respondent would vaccinate when experiencing an orf outbreak.

[∞] 'Other' responses: 3 respondents vaccinated 'in the first week of life', 4 respondents vaccinated when lambs were more than 4 weeks of age. Other respondents did not indicate a specific age but would vaccinate 'when there were enough lambs to open a bottle of vaccine'.

When asked 'Do you ever exclude animals from vaccination?' 12% (n=24/206) of respondents indicated to exclude animals. Reasons for exclusion were: animals that are sick or weak, store lambs/rams that are bought in, or animals to be sold.

When asked 'Do you separate vaccinated and non-vaccinated animals?' 73% of respondents did not (n=143/197), 27% respondents did, or did sometimes, separate vaccinated from non-vaccinated animals. This was mainly done by keeping lambs in different fields and not mixing new-born lambs before they were vaccinated.

Decision making and motivation to vaccinate

The annual flock health plan was mentioned by four respondents as an opportunity to discuss orf vaccination. Thirty-one percent of respondents (n=74/207) had discussed the use of orf vaccine with the person who supplied it in the past year.

The most frequent topics discussed were:

1. Vaccination strategy, which animals to vaccinate and when (n=14)
2. The need for vaccination and effectiveness (n=13)
3. Cost (n=11)
4. Best practice regarding administration of the vaccine (n=9)
5. Supply issues (n=3)

The main reason to use orf vaccine was to reduce the impact of orf in lambs (96%, n=199/207) and ewes (45%, n=94/207). A vet's or other farmer's recommendation was the main reason to vaccinate for respectively 14% and 5% of respondents. Nine respondents provided other reasons such as 'preventing clinical disease due to orf experienced in the past', 'preventing zoonosis', 'avoiding loss of lambs during sales season' and 'being able to show pedigree lambs'.

Concerns and reasons (not) to vaccinate

Sixty-nine percent of respondents (n=389/567) had no concerns around orf vaccination. Concerns were significantly more likely to be raised by non-vaccinating respondents; 37% of non-vaccinating respondents had concerns versus 22% of vaccinating respondents ($P<0.01$). There was no difference between respondents raising concerns or not with regards to using the vaccine correctly, 22% percent of respondents in both groups raised concerns ($P=1.00$).

The most common concerns raised by 31% of respondents (n=178/567) were:

1. Efficacy, cost-benefit (23%)

2. Risk of introducing virus, making it worse (22%)
3. Zoonotic risk (21%)
4. Once you start vaccinating, you cannot stop (12%)
5. Lack of knowledge and information to make informed decision (11%)
6. Concerns around administration technique (8%)
7. Stress, effect on animal welfare (5%)

When 345 respondents indicated not to vaccinate, the most common reasons for not vaccinating were:

1. No justifiable need, orf not present (63%)
2. Alternative management (buckets, biosecurity) (13%)
3. Not nice, hassle, time, tricky to do (11%)
4. Cost (7%)
5. Lack of efficacy (4%)
6. Fear/Experience of making it worse (cross infection) (4%)
7. Supply issue (3%)
8. Didn't know they could (3%)

Fifteen respondents mentioned they had never had orf until last year and they are planning to vaccinate or look into it for this year. Other examples of reasons not to vaccinate were:

- 'Working on theory of self-immunity'
- 'We treat with pour on. Sounds strange I know but it does work. We put a full dose between affected animals' ears which clears it up.'
- 'We only get very few cases which we treat easily with Engemycin spray'
- 'My vet says it is better to clean the fields of thistles and improve the sheep husbandry than inject a live and zoonosis type vaccine'
- 'Let the virus run its course and monitor ewes and lambs accordingly'

From 89 respondents who used to vaccinate, 86 respondents explained why they stopped vaccinating. The most common reasons for stopping were:

1. Perceived lack of efficacy or perception that problem got worse (24%)
2. Process too time consuming, difficult, burden on staff and animal (22%)
3. Perception it was not needed anymore due to increased immunity (16%)
4. Perception it was not needed anymore as management changes were made or other solutions implemented, such as closed farming, salt, orf pills/buckets, thistle control, outdoor lambing, reduced stocking density (14%)
5. Supply issues (12%)
6. Cost (9%)

The vet was the preferred source of information about orf vaccination and most respondents preferred to receive that information via email or face to face (Figure 5). Respondents preferring information from their vet (40%) or manufacturer (56%) were significantly more likely ($P<0.01$) to vaccinate compared to those preferring to receive information from AHDB (19%) or agricultural merchants (14%). There was no difference between respondents who vaccinated and those who did not with regards to preferred method to receive information ($P=0.73$).

Figure 5

Most respondents (62%) rated their vet's knowledge on orf higher than their own; 147 respondents (26%) rated their own knowledge equal or better than the vet (Figure 6). Respondents who indicated their vet had more or equal knowledge were more likely to vaccinate (38 and 45% respectively) compared to respondents who were unsure about their vet's knowledge (15%, $P<0.01$).

Figure 6

Sixty comments were provided at the end of the survey of which the majority were supporting the practical importance of this study; five relevant quotes are presented:

- 'After last year I'm seriously considering vaccination. I really would like to hear more of your research. I did contract orf myself last year. One of the effects I haven't realised is how ill it makes you feel. If lambs have same response then the effects of that are not considered in the farming press and veterinary articles. Just the scabs and secondary infection. Also your question on vet knowledge. Vets get info from books and articles but few keep sheep and observe first hand. Therefore the info from other farmers is necessary to balance this out. Thanks for doing this research'
- 'Our vets are great but I've never asked about vaccination, we've had 2 cases in 5.5 yrs. First in ewe scared us but another crofter told us what it was just treated with blue ab spray & patience, second in pet lamb but had found & bought Netex orf paste, don't know what's in it but cleared it really quickly'
- 'We have had an orf problem on farm previously where there has been an underlying problem in a couple of bought in sheep resulting in the loss of a breeding tup in one instance due to secondary infection. I'm very interested to read the results of the study.'
- 'Please can you post your findings on social media sites so we can see them also please'
- 'We would be really interested in this survey and study and would invite you to our farm and flock. We have been farming for 6 years. The first year we lambed we didn't vaccinate and it was absolutely devastating and we culled a lot of ewes because of teat scarring. It was the worst any farmer or vet had seen. It was such a relief when scabivax worked. We wouldn't dare not using it.'

Discussion

This study confirms that elements of orf vaccine administration such as site and timing of vaccination, cleanliness and the storage of vaccine are not carried out correctly on UK sheep farms, which is likely to affect vaccine efficacy. A concern around vaccine efficacy, the 'hassle' of the scratch administration, the 'risk of making it worse' and the zoonotic risk when vaccinating were the most common barriers for using orf vaccine. Participants' knowledge on what would be expected to be seen if the vaccination has successfully mounted an immune response was limited; if farmers would be better informed on what to expect as a response, they may be able to identify efficacy problems correctly. When informing farmers, considering who carries out the actual vaccination is important; the survey indicated it is often the shepherd who vaccinates and not the owner; therefore knowledge exchange (KE) needs to be directed accordingly and include the whole farm team.

Incorrect administration technique can lead to spread of virus; the recommended location is the elbow (11), surprisingly only 27% of respondents vaccinated there. There is a mastitis risk due to cross contamination when using the hindlimb region in ewes. It is discouraged to vaccinate lambs in this region as they can reach it with their muzzle and are likely to sniff a contemporary lamb in this area which could result in an infection of the muzzle and subsequently the dam's udder. Effectively informing sheep farmers of these risks can help change practice, which highlights the existing opportunities for vets to exchange knowledge on farm. There are a growing number of opportunities for vets pre- and post-graduation to further improve the communication skills required to effect change. Similar to reported for cattle farmers (15), this study indicated sheep farmers have a strong interest to learn more about vaccination. Teaching these and perhaps 'harder to reach' clients is a challenge different from veterinary science, however, a growing body of literature helps to segment farmers, explore their motivators (16) and provides further support to implement change.

Orf vaccine should not be administered to a flock which has not experienced a clinical case of orf in the past, because introducing a live virus has the potential to cause an outbreak of the disease (17) and the majority of respondents were aware of this. When vaccinating after having identified orf on the farm, some respondents raised the concern that 'they could make

things worse'; there is no published evidence to support this fear, although it may hold true when farmers vaccinate animals which are already sick and weakly, or already displaying clinical signs. The orf vaccine does not eradicate disease but reduces clinical signs and/or lesions of the disease. Immunity develops within 4-8 weeks of vaccination and is protective against severe signs of contagious pustular dermatitis for at least 12 months (11). Buddle et al. (18) investigated orf vaccine failures and indicated that complete protection even against homologous strain challenge was not achieved, however it did demonstrate that post-exposure, lesions healed more rapidly in vaccinated animals. Antigenic differences between vaccinal and field strains appear an unlikely cause of vaccination failures (18, 19).

The vaccine should be administered as a skin scratch, with enough force to break the skin but not enough to draw blood, using a proprietary orf vaccine applicator. Ewes should not be vaccinated within the last seven weeks of their pregnancy, as the scabs which will form will contain live attenuated strains of orf virus that could contaminate housing, infect the newly born lambs when they are not yet immunocompetent and result in a reduction in daily live weight gain and possible secondary infections. Lambs can be vaccinated any time after birth, but are recommended to be vaccinated within 1-3 days, as vaccination is a more controlled method of introducing orf than natural infection (20). Participants for the most part prioritised lambs over ewes in the vaccination process, and only 14% of respondents vaccinated both lambs and ewes, which corroborates findings by Onyango et al. (7). The timing and management of vaccination in both groups could be improved; it is recommended that vaccinated animals should neither be allowed access to lambing pens or pasture where ewes and their lambs will subsequently be grazed, nor allowed to come into contact with unvaccinated sheep (21). However, few participants had this separation in place. The risk of a reduced efficacy due to suboptimal timing of vaccination is a concern, indicated by the variation of vaccination strategies described by respondents.

Recommended shelf life of the product after opening is eight hours (11), however many respondents indicated to use the vaccine for up to a week after broaching a vial; the impracticalities of having to use a whole bottle was often mentioned. Poor vaccine storage

practices as found in this study were also observed on dairy farms in the UK (22, 23).

Hygiene measures taken around vaccination time were variable, but are of paramount importance when using medicines in terms of contamination of the medicine itself or the administration site, as injection site complications have been reported in sheep (24). Using disinfectant on the applicator needle during vaccination sessions will inactivate live orf vaccine; the SPC states that 'prior to first vaccination and each subsequent vaccination session, and at the end of each vaccination session, the applicator should be sterilised'. This was performed by only 27% of respondents, and 10% of respondents indicated to clean the applicator needle with disinfectant in between animals, which are areas of concern with regards to vaccine efficacy. Rubber gloves should be worn when handling orf vaccine or dismantling the applicator and hands and arms should be washed after vaccination; just over half of respondents indicated to wear gloves while vaccinating, which is concerning when using a live viral vaccine known to be a zoonosis. Areas to improve are similar to areas observed with dairy farmers (25), for whom an instruction video was developed after finding comparable compliance issues (26); a study demonstrated improved farmer knowledge after watching the video (27). Best practice measures, such as washing hands before and after vaccination, wearing gloves, cleaning the end of the needle with cotton wool, having a plastic bag for the disposal of vaccination material and sterilising the applicator with boiling water after use, may be implemented if farmers are more aware of correct technique.

Poor vaccination compliance has been noted before in the farming community; beef farmers showed similar variability in knowledge of for example site of application, when asked about cattle vaccination (28). It was interesting to note that sheep farmers appeared to know more about vaccination compared to beef farmers, despite having fewer discussions with their vet. It was encouraging to hear some respondents were excluding sick or weakly animals, which resembles findings in cattle vaccination (25). The fact that some respondents mentioned they were afraid of resistance suggests there would be value in knowledge exchange activities to promote the value of veterinary advice and education on vaccine working mechanisms for interested farmers. Farmers did not frequently discuss orf vaccination with

the person who supplies it, this reflected Cresswell's findings in cattle vaccination (23); they showed 66% of cattle farmers had discussed vaccination with their supplier, while in this study only 30% had done so in the last year. However, for 70% of respondents the vet was the preferred person with whom to discuss orf vaccination, preferably in person or via email. In this study no information was collected regarding the format by which vets were delivering information about how to vaccinate (i.e. formal training, phone advice, point of sale over the counter), which would be worth exploring as half of the respondents indicated to have learned how to vaccinate from their vet. Vets need to make sure they are confident in their own knowledge, as there were concerns by a minority of sheep farmers around the level of vet knowledge when compared to their own. Respondents who rated their vet's knowledge higher or equal to their own, were more likely to vaccinate; leadership and continuing professional education for vets can ensure this high level of knowledge is promoted throughout the profession.

Orf prevalence is reduced in flocks where the lambing season is more concentrated (7). In a short lambing season, the vaccination schedule for ewes pre-lambing and lambs from birth may be easier to manage as required by the SPC. If the lambing season is extended, lamb vaccinations become asynchronous and vaccinated animals need to be kept separate from non-vaccinated, causing increased management challenges. Although many farms (63%) did not apparently have orf on the farm and therefore would not be advised to vaccinate, there is still a proportion of farms affected by orf who do not vaccinate. Market penetration is estimated at 16% (2 and 13% ewes and lambs respectively), and the estimated prevalence of orf is higher, therefore it seems more sheep farms could benefit from vaccination. Supply issues were brought up as a reason not to vaccinate; the sheep sector can be vulnerable to the lack of availability of veterinary drugs, which can become a barrier to improving animal health and welfare. Effective communication around expectations of efficacy, cost benefit, zoonotic and animal clinical disease risk may help overcome some of the barriers observed in this study. Veterinary practices could consider offering vaccination services for clients where a lack of time, confidence or inexperience with the administration technique is a

barrier. Various 'easier/better' alternative techniques were used, which cannot be recommended because of the lack of efficacy data. Respondents mentioned the use of various alternative treatments (pour-on, iodine, oxytetracycline spray, pastes, creams); farmers may mistake self-cure of the disease or a reduction in signs of secondary infection for 'treatment efficacy' and therefore perpetuate the view that vaccination is not required. This then becomes a barrier to vaccination; communication with clients on their reasons not to vaccinate and correct knowledge exchange about effective treatment is a crucial part of the vet's work. Evidence-based veterinary advice on the possible implications of off-label application could help farmers to better understand the importance of using products according to the SPC. The majority of respondents indicated they would follow datasheet recommendations, similar to dairy and beef farmers (25), however the frequency of 'incorrect use' demonstrates that farmer behaviour does not always match their intention.

As a large majority of respondents completed the survey online, the results will have a bias towards those who are comfortable with IT. The results may not be representative for the UK sheep farming population; women appeared over-represented compared to similar demographics in related studies (25, 29) and a large proportion of respondents had a FE or HE qualification. However, other demographics were representative of the industry, and the qualitative information combined with the large number of respondents provide rich and novel information.

Aside from aiming to attract a random population of vaccinating sheep owners by using an online survey and developing unbiased questions, there was no further bias control. A recall and response bias may have occurred as respondents may not remember exactly what they did and could 'look up answers' if they wished to do so. However, as the study was anonymous there was no incentive to do so. The recall bias was not considered a major limitation, as the questions were purposely not compulsory to answer and analysis showed that sometimes questions were not completed; which may have been due to respondents not remembering or knowing the answer. In addition, many respondents had been vaccinating for a long time. The study was biased by respondents who may have had a more

than usual interest in orf. This bias would likely lead to an underestimation of the results, i.e. in areas of poor administration practice this would be expected to be worse in an unbiased population. Due to the online distribution of the survey a response rate could not be calculated; 507 respondents represent 0.7% of the 70,577 sheep holdings in the UK (30). One therefore needs to consider the external validity and be careful to extrapolate results to all UK sheep farmers.

The survey had an excellent online uptake in a short timeframe, and many respondents showed interest in the results. The key elements of poor compliance identified in this study should be included when communicating and training users. Innovative methods of communication geared towards the target audience will facilitate uptake of best practice. A collaborative effort between industry stakeholders such as AHDB Beef and Lamb, the pharmaceutical industry, the practising veterinary profession, and knowledge exchange professionals can provide promising opportunities to combine digital and face to face delivery of key messages identified in this study.

Conclusions

Even though there was a sincere respondent interest in the topic, key elements of orf vaccine administration such as site and timing of vaccination, cleanliness and the storage of vaccine were not carried out correctly on UK sheep farms, which is likely to affect vaccine efficacy. A concern around vaccine efficacy, the 'hassle' of the scratch administration, the 'risk of making it worse' and the zoonotic risk when vaccinating were the most common barriers for using orf vaccine, highlighting the importance of veterinary advice when prescribing orf vaccine.

Acknowledgements

Many thanks go out to all respondents, along with the vet practices that aided in the distribution, and AHDB Beef and Lamb for allowing the authors to attend the Challenge Sheep Discussion Group meetings.

Author contributions

Conceptualisation of the study: CMQ, SS, FL, JO, WW. Data collection: CMQ, SS, FL. Data analysis and interpretation: CMQ, EG, LC, SS, FL, JO, WW. Manuscript writing: SS, LC, FL, CMQ, WW. All authors were involved in critical review and editing of the final manuscript.

Funding

The study was supported by the MSD Animal Health and the University of Nottingham.

Competing interests

SS declares that she is employed by MSD Animal Health. CMQ, EG, LC, FL, JO and WW declare that they have no conflict of interest.

Ethics approval

This project was approved by the University of Nottingham School of Veterinary Medicine and Science Ethics Committee.

Supplementary materials

PDF of survey

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